Epidemiology and Symptomatology of Staphylococcus Food Poisoning*

A Report of Recent Outbreaks

GEORGE A. DENISON, M.D., F.A.P.H.A.

Director of Laboratories, Jefferson County Board of Health, Birmingham, Ala.

FOOD poisoning due to staphylococci was first reported by Barber [1] in 1914. At the present time 18 outbreaks have been recorded in which the offending staphylococci were shown to be toxic for man or monkey—by the ingestion of milk or broth cultures in 3 instances, and by the ingestion of filtrates in 15 instances. The incriminated foods have been cake and custard-filled or cream-filled bakery goods [2, 6, 7, 8, 10] in 10 outbreaks, raw milk [1, 4, 12, 13] in 4, while cheese,[3] chicken gravy,[5] chicken salad,[9] and tongue sandwiches,[11] were each responsible for a single outbreak. In addition there remains a significant number of food poisoning outbreaks in which staphylococci were thought, for good reasons, to have been the etiological factor though full confirmation is lacking.

The following report of recent outbreaks of food poisoning serves as a reminder of the growing importance of the problem, and is perhaps of value for the added clinical information it may contain.

On the morning of March 27, 1936, a Birmingham physician reported to the Board of Health that he had attended 12 Ensley high school students, all sick with food poisoning after eating cream puffs for lunch on the 26th. The severity of the illness varied though all had the same general symptoms.

Investigation disclosed that the school lunch-room was clean, and its operations met the sanitary requirements of the Board of Health. The lunch-room personnel had not recently changed, none had been ill, and bacteriological examinations (completed 6 months previously) had not disclosed carriers of intestinal pathogens.

For several months the lunch-room had served cream puffs purchased from the same bakery. On the day of the outbreak 18 dozen had been purchased; 4 dozen of these were taken from the school to a neighboring café where most of them were later recovered. There were 693 students fed; 165 ate cream puffs, and 94, or 57 per cent, of these were taken ill. The 528 students who did not eat cream puffs were not sick. Six additional cases developed from cream puffs taken home by lunch-room supervisors and eaten by individuals for the evening meal. In all, 122 cases were discovered, 94 from the school, 8 from cream puffs carried away

* Read at a Joint Session of the Laboratory and Food and Nutrition Sections of the American Public Health Association at the Sixty-fifth Annual Meeting in New Orleans, La., October 24, 1936.

from the school, and 20 from cream puffs sold to 3 cafés and from the bakery truck.

It seems significant that, among 65 students who became ill after eating cream puffs for dessert, following the ingestion of other food, the onset was somewhat more delayed, and the illness decidedly more severe than among 29 who ate only cream puffs. Variations in the concentration of the gastric juice may partly explain apparent differences in susceptibility of these students to enterotoxin. Borthwick [14] states that the active principle of toxic staphylococcus filtrate is destroyed or reduced at a pH lower than 6.8 or higher than 7.8, and he reports rendering guinea pigs suceptible by adjusting the reaction of the stomach contents to a pH of 7.3.

Detailed clinical histories were obtained from both the victims and their attending physicians. The more typical cases may be described as follows:

Within 2–4 hours after eating there was first noticed a feeling of nausea. Severe abdominal cramps developed and were quickly followed by vomiting which was severe and continued at 5–20 minutes intervals for 1–8 hours. The vomitus was blood streaked in 13 per cent of the cases. A diarrhea of 1–7 liquid stools usually began with the vomiting or several hours after its onset. Blood, not infrequently, was present in the stool. During the acute stage the temperature was normal or subnormal, the pulse noticeably increased, there were cold sweats, prostration was severe, and the patients were very definitely in a state of shock. Headache was mild and of a short duration. Muscular cramping, usually of the flexors of the legs, was present in the majority. Dehydration was marked in some.

While the acute symptoms usually lasted only 1–8 hours complete recovery, because of prostration, was delayed for 1–2 days. During this time temperatures of 100° were not uncommon. Three cases were hospitalized. There were no fatalities.

These symptoms with their variations are summarized as follows: The most common interval between eating and the onset of illness was 3 hours. Eighty per cent were ill by the 4th hour, while in a small number the onset was delayed for 6, 7, and 8 hours. Twenty-one per cent were ill only for the short period of 1–4 hours while in 36 per cent recovery was delayed for 25–48 hours. Vomiting was the most

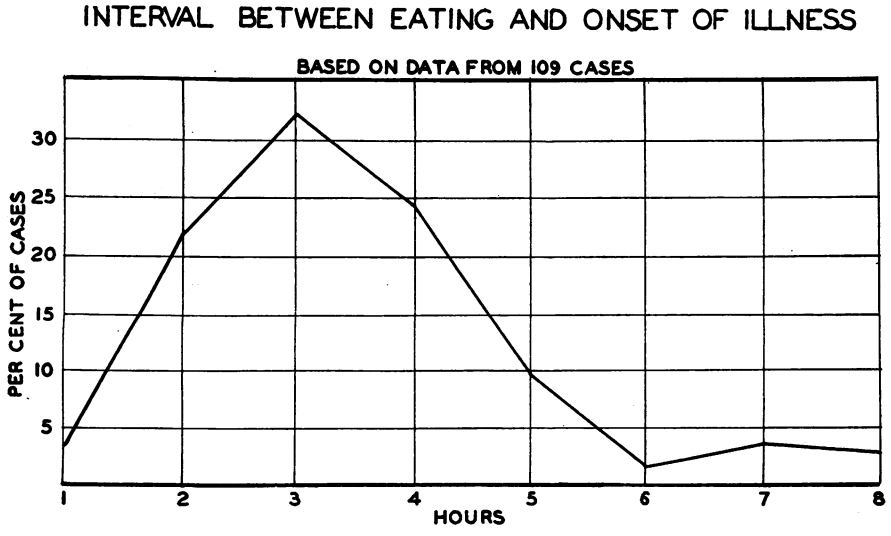


FIGURE I—Interval Between Eating and Onset of Illness

pronounced symptom, and in 50 per cent was described as "continuous." In the majority of cases (92 per cent), however, vomiting had ceased within 5–8 hours. There was severe vomiting in 78.2 per cent, severe abdominal pains in 62.5 per cent, mild diarrhea (1–7 stools) in 72.8 per cent, mild and usually transient headache in 58 per cent, mild muscular cramps in 51.3 per cent and sweating in 67 per cent. Prostration, dehydration, and the degree of shock varied accordingly.

TABLE I

SYMPTOMS OF FOOD POISONING

	Information from No. of Cases	*None* %	*Mild* %	*Severe* %
Vomiting	122	12.1	9.7	78.2
Pains in abdomen	122	4.7	32.8	62.5
Diarrhea	103	12.6	72.8	14.6
Headache	101	29.0	58.0	13.0
Muscular cramping	113	36.3	51.3	12.4
Sweating	100	33.0	67.0	

It should not be inferred from this discussion that the clinical features of staphylococcus food poisoning are distinguishable from those of Salmonella food poisoning, for such is not the case, only bacteriological studies are dependable. It is true, however, that the onset of illness in outbreaks due to the staphylococcus is usually within 2–4 hours after eating, and those due to the Salmonella group usually 12 hours or longer.

On inspection the bakery which furnished the cream puffs was filthy. Not only this, but certain conditions which prevailed were disgusting if not positively revolting. Three grossly insanitary toilets were repugnant and obnoxious. The building was not fly-proof and flies were embracing these toilets and the bakery products as a regular rendezvous. There were no proper washing facilities for the 35 employees, and no hot running water on the premises. Wash water for the utensils had the consistency of pea soup, no rinse was used, and the utensils were subsequently wiped with a dirty cloth. The greater part of the large and small equipment was inadequate, improvised, covered with filth, and in such a state of disrepair as to render cleansing impossible even under the best of conditions.

Raw materials were stored in open barrels entirely unprotected from dust, rats, and insects. The finished bakery products were subject to promiscuous handling and, before being wrapped, were often collected in an open garage within 15 feet of the insanitary toilets. Clothing worn by the employees was filthy. There was no history of recent illness, nor of boils or abscesses among the personnel. Such circumstances were not surprising, however, when we consider that for 3 years there had been no routine inspection of food establishments by the Board of Health because of severe financial restrictions. Other bakeries, inspected at a later date, were even more filthy—if such were humanly possible.

The cream puffs in question were all of one batch. The cream filling (approximately 12 gallons) had been heated in a copper kettle by steam for 6 minutes and then allowed to cool for 2½ hours before being placed in the shells. The heating temperature was indefinite and it is questionable whether the filling was rendered reasonably sterile. The time and conditions allowed for cooling were ideal for bacterial multiplication.

Nineteen cream puffs were examined. On physical inspection all appeared to be fresh. Direct microscopic examination of the filling showed large numbers of staphylococci and spore-forming bacteria. Agar plate counts on 4 specimens showed a bacterial content of 50 to 70 million per gram; 99 per

cent of these organisms were *Staphylococcus aureus*. From all 19 specimens *Staphylococcus aureus* was found in abundance, and in all *B. coli Communis* was also present. No bacteria of the Salmonella group were isolated and no carriers of these pathogens were found among the bakery personnel.

Jordan [3] has shown that staphylococci of diverse origin and cultural characteristics are capable of producing a filterable enterotoxin. Stritar and Jordan [15] conclude that there are no good criteria for the differentiation of various types of staphylococci and that in " food poisoning strains " there is no homogenicity of biochemical, hemolytic, or agglutinative characters. From studying a number of strains of staphylococci Woolpert and Dack [16] found that enterotoxin was not formed without the production of other exotoxins and that there seemed to be a rough correlation between the amount of food poison and the amounts of other toxins; these facts are borne out in this investigation.

Nineteen cultures of *Staphylococcus aureus* isolated from different cream puffs fermented maltose, dextrose, lactose, mannite, rhamnose, saccharose, and sorbite without gas; 6 fermented salicin after 1 week; none fermented xylose or inulin. All were hemolytic on blood agar. An antiserum made from one culture (C-3) agglutinated the remaining 18 cultures in amounts varying from 1/8 to 1/2 of the serum titer. These characteristics were the same for both enterotoxin producing and non-enterotoxin producing organisms.

Filtrates of 16 cultures were prepared according to Dolman's [17] modification of Burnet's method. Filtration was through Seitz pads (discarding the first portion of each filtrate) though Woolpert and Dack [16] have shown that these pads adsorb appreciable amounts of exotoxin. When tested with 1 per cent rabbit erythrocytes 5 filtrates produced no hemolysis, 10 were only slightly hemolytic when undiluted, while 1 (C-3) produced complete hemolysis in a dilution of 1/50. Using 2 rabbits, a filtrate of culture C-3 produced dermonecrosis in dilutions of 1/100 and 1/25. Filtrates of other cultures produced little (dilution of 1/5) or no dermonecrosis.

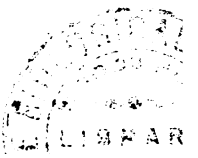
Filtrates for feeding experiments were prepared from broth cultures grown either in air or in 10 per cent

TABLE II

FEEDING EXPERIMENTS WITH BROTH FILTRATES OF STAPHYLOCOCCUS AUREUS ISOLATED FROM CREAM PUFFS

Culture	*Filtrate*	*Individual*	*Result*
C-6	6 c.c. 24 hr. broth	A	Not toxic
	20 c.c. 24 hr. broth	C	Abdominal cramps, headache
	6 c.c. 48 hr. broth	A	Not toxic
	12 c.c. 48 hr. broth	E	Not toxic
R-7	6 c.c. 24 hr. broth	D	Not toxic
	20 c.c. 24 hr. broth	E	Abdominal cramps, 6 liquid stools
	6 c.c. 48 hr. broth	E	Not toxic
	12 c.c. 48 hr. broth	A	Not toxic
R-1 *	10 c.c. 48 hr. broth	A	Not toxic
R-2 *	10 c.c. 48 hr. broth	B	Not toxic
C-2 *	10 c.c. 48 hr. broth	C	Not toxic
C-3 *	10 c.c. 48 hr. broth	E	Toxic (case E)
*	24 c.c. 48 hr. mixed	D	Toxic (case D)

* Grown in 10 per cent CO_2



carbon dioxide for 24–28 hours, and then passed through Seitz pads. In this way, and by graduating the dose, we hoped to produce filtrates only mildly toxic for human volunteers. Filtrates were diluted with 8 oz. of milk just before drinking. An equal number of controls took sterile broth in milk and none reacted. Human susceptibility to enterotoxin varies, and the number of persons used in feeding experiments was probably inadequate to prove the presence or absence of enterotoxin production in some of the strains tested.

Twenty c.c. of a 24 hour broth filtrate of staphylococci from two different cream puffs proved mildly toxic when fed to 2 individuals. One experienced mild headache and abdominal cramps, the other, abdominal cramps and 6 liquid stools. The onset for each was 3 hours. Other individuals receiving smaller amounts of 24 and 48 hour broth filtrates were not affected.

Cultures from each of 4 cream puffs were then grown in broth in an atmosphere of 10 per cent carbon dioxide for 48 hours and filtered. Ten c.c. of these filtrates were fed to 4 individuals while a 5th took 6 c.c. each of the filtrates from all 4 cultures, a total of 24 c.c. Three individuals were not affected.

Individual "D" who took the mixed filtrate was nauseated after 3½ hours, vomited 4 times in the course of 1 hour, the temperature dropped to 97.2° and pulse increased from 80 to 112. The white cell count rose to 15,000, blood pressure remained normal, and there was no diarrhea, prostration, dehydration, or abdominal rigidity. Recovery was complete in 4 hours.

Individual "E", who took 10 c.c. broth filtrate of culture C-3, was desperately ill for 3 hours. Nausea and vomiting developed 2 hours 45 minutes after drinking the filtrate. Vomiting was severe (5 times in the 1st hour). There were 5 liquid stools, 2 containing blood. Pallor was marked, the temperature fell to 96°, and the pulse rose from 84 to 130. Blood pressure fell from 120/80 to 60/40, the white cell count rose to 21,400 with 81 per cent polymorphonuclears. Headache

TABLE III

CASE "D"

Time	*Temp.*	*Pulse*	*Blood Pressure*	*White Count*	*Per Cent Polymorphonuclears*	
0	98.6	80	116/80			Drank 6 c.c. each of broth filtrates from cultures R1, R2, C2, C3. Total 24 c.c. in 8 oz. milk.
0:30						Ate light lunch
3:20 *						* Nausea and abdominal cramps
3:30			116/80			Vomited
3:40						Vomited
3:55						Vomited
4:00	97.2	112	116/80	12,200	71	
4:20						Vomited
4:30	97.8	80	116/80			
6:00				15,000		Recovered except for slight weakness
7:00						Complete recovery

* Onset 3 hrs. 20 min. after drinking broth filtrate. Nausea and abdominal cramps continued for 2 hrs.

TABLE IV

CASE "E"

Time	Temp.	Pulse	Blood Pressure	White Count	Per Cent Polymorphonuclears	
0	98.6	84	120/80			Drank 10 c.c. broth filtrate of culture C-3 in 8 oz. milk. Did not eat lunch.
2:45						* Nausea and abdominal cramps, slight dizziness
3:00						Vomited, large liquid stool, marked pallor
3:15						Vomited
3:30						Vomited, liquid stool
3:40						Vomited
4:00	97.4	120				Vomited, liquid stool
4:30	97.4	120				
5:00	96.0	110				
5:30	96.0	100	75/55	21,400	81	Bloody liquid stool
6:00	97.4	108	75/55			
6:30	97.0	130	60/40	16,400	77	Bloody liquid stool
9:00	98.6	110				Marked prostration

* Extreme nausea, abdominal cramps, and prostration continued for 4 hours from onset.

was mild at the onset and of short duration, there were cold sweats, and prostration was severe. There was no abdominal rigidity. Dehydration was moderate but probably did not entirely account for the increased white count. The acute symptoms passed in 4 hours but weakness persisted for 2 days.

The findings in these two experimental cases follow those of the mild and severe cases of food poisoning experienced in this outbreak and appear to establish *Staphylococcus aureaus* as the cause. The opportunities for contamination of the bakery products were so numerous that it seems highly improbable that the source of the infection can ever be determined. Cultures of staphylococci were isolated in large numbers from the throat of one of the bakery personnel, from various parts of the machinery, and from the feces of 1 patient. Their broth filtrates were not toxic with feeding tests.

The bakery was cleaned up and continued to operate. On May 11, 3 individuals, living in different sections of the city, were admitted to a local hospital severely ill with food poisoning. The symptoms were the same as those described for the first outbreak. All had subnormal temperatures and white cell counts above 10,000 (10,750 with 84 per cent, 11,850 with 78 per cent, 38,800 with 89 per cent polymorphonuclears). In addition each had marked abdominal rigidity (board-like in 2) and the general picture was that of an acute abdominal condition requiring surgery. In fact, a pre-operative diagnosis of "ruptured peptic ulcer" was made on 1 patient and a laparotomy performed.

Each patient had eaten in a different café and had partaken of cocoanut custard pie baked by the bakery involved in the first outbreak. Portions of two pies eaten by 2 individuals were recovered and found to contain enormous numbers of *Staphylococcus*

aureus. Twelve other persons were thought to have eaten portions of three pies involved but no other cases could be discovered. Following this incident, the bakery has been permitted to bake only bread and rolls.

It should be realized that the number of reported cases of food poisoning falls far short of indicating the frequency with which sporadic cases result from contaminated, commercially prepared foods. Due to publicity given recent outbreaks in Birmingham numerous suspected cases of a sporadic nature have come to our attention, and we have every reason to believe that during the summer months such cases are of daily occurrence.

By way of controlling such outbreaks certain practices common to many bakeries should be eliminated. They have been emphasized in other reports but may well be repeated here. Custard-filling in the usual course of its preparation is heated to temperatures at which staphylococci will not survive, and failure to destroy the organism is evidence of improper cooking. Dack [2] has shown that the organisms in broth culture are destroyed by exposure to 80° C. for 15 minutes. McBurney [7] found that as many as 2,500,000 staphylococci per c.c. of liquid custard were killed by cooking at 85° C. for 10 minutes. To avoid contamination after cooking the filling should be properly covered, and cooled at refrigerator temperatures. Excessive handling of the shells or the filling should be avoided, and all machinery used should be thoroughly cleansed and properly sterilized. The finished product should be properly covered or wrapped, and stored at refrigerator temperatures. Obviously the building should be fly proof, and reasonably free of rodents and insects. Proper toilet facilities should be provided for the personnel. Machinery and equipment should be adequate to handle the volume of business undertaken.

Adequate inspection service, aside from checking all physical equipment, must exert some supervision over the methods of preparation and distribution of the food products. Those bakeries which cannot reasonably comply with regulations because of antiquated and improper physical equipment, or who refuse to comply for other reasons, should, at least, be promptly prohibited from making any product not subjected to the same oven temperatures as bread and rolls.

No matter how essential certain requirements may appear to the inspector they always seem unreasonable to the proprietor unless he understands why they are made. While educational programs are necessarily slow and time consuming, more progress can be expected if the proprietor understands how such control measures protect his business, as well as the public. Unless coöperation is obtained, inspection service reverts to purely police methods which are undesirable and often ineffective. Outbreaks frequently occur in bakeries that are scrupulously clean but where some breach of technic has presumably occurred. Educational programs directed toward plant operators and their personnel are, therefore, of considerable importance. Medical examinations and bacteriological attempts at detecting carriers would, as a routine measure, seem to offer little of definite value.

Finally, in the many cities where inadequate appropriations allow only a pretense at actual control of food products, it seems essential that the greatest effort be directed toward those small and large establishments which prepare, manufacture, and distribute foods, rather than the small retailers who may dispense products already contaminated before reaching their hands.

REFERENCES

1. Barber, M. A. Milk Poisoning Due to a Type of Staphylococcus Albus Occurring in the Udder of a Healthy Cow. *Phillipine J. Sci.*, 9:515, 1914.
2. Dack, G. M., Cary, W. E., Woolpert, O., and Wiggers, Hazel. Outbreak of Food Poisoning Proven to Be Due to Yellow Hemolytic Staphylococcus. *J. Prev. Med.*, 4:167–175 (Mar.), 1930.
3. Jordan, E. O. The Production by Staphylococci of a Substance Producing Food Poisoning. *J.A.M.A.*, 94:1648 (May 24), 1930.
4. Ramsey, R. J., and Tracey, P. H. Food Poisoning Probably Caused by Orange Colored Staphylococcus from Udder of Apparently Healthy Cows. *Proc. Soc. Exper. Biol. & Med.*, 28:390 (Jan.), 1931.
5. Jordan, E. O., and Hall, J. R. *J. Prev. Med.*, 5:387 (Sept.), 1931.
6. Jordan, E. O. Staphylococcus Food Poisoning. *J.A.M.A.*, 97:1704 (Dec. 5), 1931.
7. McBurney, Ralph. Food Poisoning Due to Staphylococci. *J.A.M.A.*, 100:1999 (June 24), 1933.
8. Jordan, E. O., and Burrows, William. Further Observations on Staphylococcus Food Poisoning. *Am. J. Hyg.*, 20:604 (Nov.), 1934.
9. Haynes, Harley A. Food Poisoning—What May Cause It and What May Prevent It. *Mod. Hosp.*, 44:118 (Mar.), 1935.
10. Corpening, A., and Foxhall, Elsie P. Outbreak of Food Poisoning Probably Due to Staphylococcus Aureus. *A.J.P.H.*, 25:938 (Aug.), 1935.
11. Dack, G. M., Bowman, George W., Harger, R. N. An Outbreak of Food Poisoning Apparently Due to Staphylococci. *J.A.M.A.*, 105:1598 (Nov. 16), 1935.
12. Shaughnessy, H. J., and Grubb, T. C. Staphylococcus Food Poisoning. *J. Infect. Dis.*, 58:318 (May–June), 1936.
13. Crabtree, James A., and Litterer, William. Outbreak of Milk Poisoning Due to a Toxin-producing Staphylococcus Found in the Udders of Two Cows. *A.J.P.H.*, 24:1116 (Nov.), 1934.
14. Editorial, *J.A.M.A.*, 104:1332 (Apr. 13), 1935. Borthwick, G. R. Experimental Observations on Toxic Effects of Staphylococcal Filtrates. *Brit. J. Exper. Path.*, 14:236 (Aug.), 1933.
15. Stritar, Joseph, and Jordan, E. O. Is a Special Variety of Staphylococcus Concerned in Food Poisoning? *J. Infect. Dis.*, 56, 1 (Jan.–Feb.), 1935.
16. Woolpert, O. C., and Dack, G. M. Relation of Gastro-intestinal Poison to Other Toxic Substances Produced by Staphylococci. *J. Infect. Dis.*, 52, 6 (Jan.–Feb.), 1933.
17. Dolman, C. E. Ingestion of Staphylococcus Exotoxin by Human Volunteers. *J. Infect. Dis.*, 55:172 (Sept.–Oct.), 1934.

Scarlet Fever Control

LAST February, Dr. Hobson of Oxford published a most interesting series of cases and observations. He found that:

1. An erythema is inconstant in infections due to a haemolytic streptococcus.
2. It may be a feature of those due to a non-haemolytic streptococcus.
3. Though it is more frequent in infections due to haemolytic streptococci, it is a poor guide to the course, prognosis, or infectivity of the disease in a given patient.
4. Infections due to haemolytic streptococci *with or without an erythema,* are generally highly toxic, highly infectious, and have a striking association with sequelae of all kinds. *The appearance of an erythema is probably a favourable sign.*
5. An infection due to a non-haemolytic streptococcus may have sequelae in no way distinguishable from those due to a haemolytic strain, whether there is an erythema or not.

If, as he says, these statements and conclusions are sound—and they have not been refuted so far—then it is pertinent to consider what alterations in, or modifications of, existing practice and teaching should be introduced.—Andrew W. Forrest, M.A., M.D., Ch.B. (Edin.), D.P.H., Scarlet Fever Control on Modern Lines. Presidential Address at a joint meeting of the Home Counties Branch and the Fever Hospital Medical Service Group, *Pub. Health*, 49, 12:413 (Sept.), 1936.